Public Review Draft..............August 15, 2000

**United States**
**Environmental Protection Agency**
**Region 10**
**1200 Sixth Avenue**
**Seattle, Washington 98101**

# Total Maximum Daily Load (TMDL) for Fecal Coliform Bacteria in the Waters of Duck Creek in Mendenhall Valley, Alaska

In compliance with the provisions of the Clean Water Act, 33 U.S.C. §1251 et seq., as amended by the Water Quality Act of 1987, Public Law 100-4, the Environmental Protection Agency is establishing a Total Maximum Daily Load (TMDL) that will result in a decrease in fecal coliform contamination in Duck Creek to comply with the designated uses in Alaska's water quality standards.

This TMDL will become effective immediately. Subsequent actions must be consistent with this TMDL.

Signed this __________ day of __________, 2000.

____________________
**Randall F. Smith**
**Director**
**Office of Water**

**United States**
**Environmental Protection Agency**
**Region 10**
**1200 Sixth Avenue**
**Seattle, Washington 98101**

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August 15, 2000

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**TMDL AT A GLANCE:**

| | |
|---|---|
| *Water Quality-limited?* | Yes |
| *Hydrologic Unit Code:* | 19010301 |
| *Standard of Concern:* | Fecal coliform bacteria |
| *Designateds Use Affected:* | Water supply; water recreation; growth and propagation of fish, shellfish, and other aquatic life, and wildlife |
| *Environmental Indicator:* | *E. coli* monitoring |
| *Major Source(s):* | urban runoff, including domestic animal and wildlife waste |
| *Loading Capacity:* | $2.34 \times 10^{11}$ FC/yr at the mouth of Duck Creek |
| *Wasteload Allocation:* | No point sources; wasteload allocation set to zero |
| *Load Allocation:* | $2.23 \times 10^{11}$ FC/yr at the mouth of Duck Creek |
| *Margin of Safety:* | Explicit MOS of 5 percent; implicit MOS through conservative assumptions |

## Executive Summary

Duck Creek is listed on the 1998 303(d) list of impaired waters in Alaska for fecal coliform bacteria. The primary sources of fecal coliform bacteria in the creek are urban runoff and animal waste. As the watershed has become more developed, urban runoff and pet populations have increased. Based on the water quality standards for fecal coliform bacteria and the hydrologic conditions of Duck Creek, the loading capacity for fecal coliform bacteria was estimated at 2.34 x $10^{11}$ FC/yr. It is recommended that proposed wetland, streamflow, and streamside restoration projects be carried out to reduce the inflow of fecal coliform bacteria to the creek and to increase baseflow in the creek. In addition, pet owners should be encouraged to cleanup and properly dispose of pet waste, and best management practices should be employed to control urban runoff.

## Overview

Section 303(d)(1)(C) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 CFR Part 130) require the establishment of a Total Maximum Daily Load (TMDL) for the achievement of state water quality standards when a waterbody is water quality-limited. A TMDL identifies the degree of pollution control needed to maintain compliance with standards and includes an appropriate margin of safety. The focus of the TMDL is reduction of pollutant inputs to a level (or "load") that fully supports the designated uses of a given waterbody. The mechanisms used to address water quality problems after the TMDL is developed can include a combination of best management practices and/or effluent limits and monitoring required through National Pollutant Discharge Elimination System (NPDES) permits.

The state of Alaska identified Duck Creek as being water quality-limited because of low dissolved oxygen, excess debris, metals (iron), fecal coliform, and turbidity (ADEC, 1998). A TMDL for turbidity was completed in December of 1999 (USEPA, 1999). This document addresses only the fecal coliform impairment to the creek.

The Duck Creek Advisory Group (DCAG), which was formed to coordinate, plan, initiate, and carry out activities to restore water quality and anadromous fish habitat, has drafted the Duck Creek Watershed Management Plan (DCMP). The DCMP states that urban runoff is among the most problematic of impairments to Duck Creek (Koski and Lorenz, 1999). The primary source of fecal coliform in urban runoff is animal waste, primarily from ducks and dogs (ADEC, personal communication, July 7, 2000).

Alaska's water quality standards designate the following uses of Duck Creek that must be protected: (1) water supply, (2) water recreation, and (3) growth and propagation of fish, shellfish, and other aquatic life, and wildlife (Alaska Administrative Code [AAC] § 18.70.050). Protection from fecal coliform and other pathogenic contamination is most important for waters designated for the first two of these uses. The presence of any fecal indicators indicates that a water supply is potentially unsafe for consumption. Also, excessive amounts of fecal bacteria in surface water used for recreation have been known to indicate an increased risk of pathogen-induced illness to humans. Illnesses due to pathogen-contaminated recreational waters include gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases (USEPA, 1986).

## General Background

Duck Creek is located in Juneau, Alaska, in the Mendenhall Valley, a watershed that drains several streams into one of only a few major estuarine wetlands in Southeast Alaska (Figure 1).

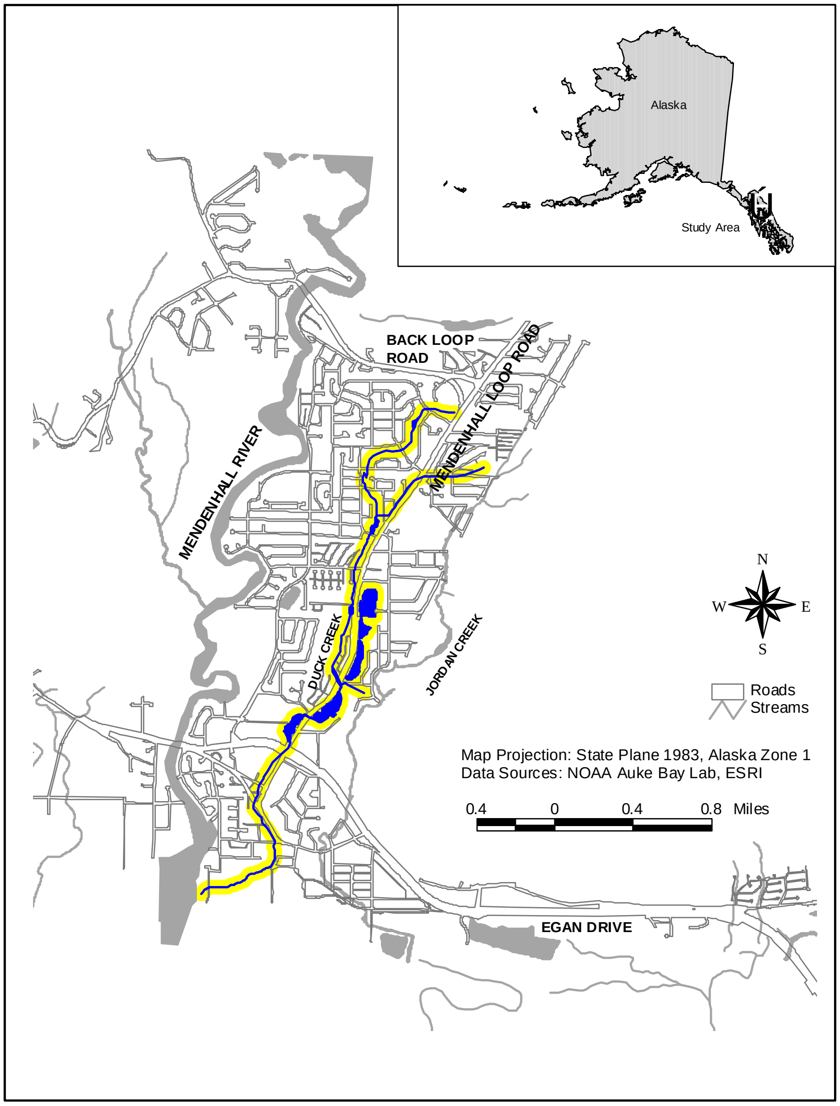


**Figure 1.** Location of Duck Creek

The Duck Creek watershed receives runoff and groundwater primarily from the floor of this large glacial valley. Duck Creek is a small stream of just over 3 miles in length that flows south through the middle of the heavily populated valley and enters the Mendenhall River and wetlands directly upstream of the Juneau International Airport runway. The creek is an anadromous fish stream (Alaska Department of Fish and Game Catalog No. 111-59-10500-2002) that historically supported runs of coho, pink, chum, and sockeye salmon. Based on descriptions from early residents, the creek originally had numerous beaver ponds and clear water that flowed year-round. Currently, the creek varies from about 5 to 15 feet in width and from a few inches to several feet in depth. Duck Creek has two main tributaries—East Fork and El Camino.

### Land Use

Thirty-six percent of the 1,080-acre Duck Creek watershed is covered by impervious surfaces such as roofs, roads, and parking lots (Lorenz, 1998). The remainder is a mix of cultivated landscaping, nonvegetated athletic fields, natural vegetation, and wetlands. Nearly half of the watershed provides space for residential housing, yards, and driveways. Most of the housing is single-family construction. Another third of the watershed is used for transportation and commercial interests. Based on this land use distribution, the Duck Creek watershed was divided into the following land use categories and areas: residential (540 acres), transportation and utilities (83 acres), commercial (282 acres), and recreation and wetland (175 acres.) Table 1 summarizes the land use distribution.

**Table 1.** Land use distribution in the Duck Creek watershed

| Land Use | Area (acres)[a] |
|---|---|
| Residential | 540 |
| Transportation | 83 |
| Commercial | 282 |
| Recreation/Wetland | 175 |
| **Total** | **1,080** |

[a] Estimated from land uses and information presented by Lorenz (1998).

The Duck Creek watershed is highly urbanized. Urban runoff is often a significant contributor of fecal coliform bacteria. The main source of fecal coliform bacteria in urban runoff in the Duck Creek watershed is animal waste, from both wildlife and domestic animals.

### Climate

Historical climate data are available from the Juneau International Airport (Station 504100), adjacent to the lower reach of Duck Creek. The temperature ranges from a normal daily minimum temperature of 19 EF (-7.2 EC) in January and 48 EF (8.9 EC) in July to a normal daily maximum temperature of 29 EF (-1.7 EC) in January and 64 EF (18 EC) in July. Rainfall averages 54 inches per year, ranging from less than 3 inches per month to well over 7 inches per month. Snowfall averages 99 inches per year, ranging from 0 to 26 inches per month. Wind averages about 8 mph daily (NOAA National Climate Data Center).

The meteorological station at the Juneau airport tends to underestimate rainfall in the Duck Creek watershed (ADEC, personal communication, August 1, 2000). In addition, the record available at the Juneau station consists of daily values, while the model selected for this TMDL requires hourly precipitation input. As a result, the precipitation data used in the model described below were based two other stations thought to be more representative of the rainfall in the watershed.

## Applicable Water Quality Standards

Water quality standards designate the “uses” to be protected (e.g. drinking water, recreation, fish and wildlife habitat) and the “criteria” for their protection (e.g. how much of a pollutant can be assimilated by a waterbody without impairing its designated uses). TMDLs are developed to meet applicable water quality standards. Standards may be expressed as numeric water quality targets, narrative standards for the support of designated uses, and other associated indicators of support of beneficial uses. The numeric target identifies the specific goals or endpoints for the TMDL that equate to attainment of the water quality standard. The numeric target may be equivalent to a numeric water quality standard where one exists, or it may represent a quantitative interpretation of a narrative standard. This section reviews the applicable water quality standards and identifies an appropriate numeric indicator and an associated numeric target level for the calculation of the TMDL.

### Designated Uses

Designated uses for Alaska’s waters are established by regulation and are specified in the State of Alaska Water Quality Standards (18 AAC 70). For fresh waters of the state, these designated uses include (1) water supply, (2) water recreation, and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife. Duck Creek only partially supports these designated uses.

### Parameters of Concern

The Alaska 1998 § 303(d) list of impaired waters identified Duck Creek as water quality-limited because of dissolved oxygen, debris, metals (iron), fecal coliform bacteria, and turbidity. This TMDL addresses only the fecal coliform bacteria impairment to the creek.

### Applicable Water Quality Criteria and Numeric Target

Water quality criteria are developed for each designated use and give guidance on how much pollution a waterbody can accommodate by while still supporting the designated uses. The most stringent of Alaska's water quality standards with respect to fecal coliform bacteria (FC) is for drinking, culinary, and food processing water supply. The applicable standard states that

> *In a 30-day period, the geometric mean may not exceed 20 FC/100 mL, and not more than 10% of the samples may exceed 40 FC/100mL. (18 AAC 70 (1)(A)(i))*

EPA anticipates approving this proposed standard prior to finalizing this TMDL. Should EPA not approve this standard, the TMDL will be modified accordingly.

The FC standard in Duck Creek, which is designated for use as a drinking water supply, is therefore a 30-day geometric mean of 20 FC/100mL, with no more than 10 percent of the samples exceeding 40 FC/100mL. Sufficient data are not available to determine the frequency of exceedance of the geometric mean standard. Of the 29 fecal coliform observations available for Duck Creek, 5 exceed 40 FC/100mL, representing 17 percent of the samples.

### Critical Conditions

Understanding when a waterbody is most vulnerable to pollutant loadings is critical to developing load reduction scenarios that will result in attainment of water quality standards. In Duck Creek, most exceedances of the fecal coliform water quality standard coincide with high flows, which indicates that nonpoint sources associated with storm water runoff contribute to the impairment. When an impairment is the result of point source contributions, it is usually most pronounced at low flows. This is because point source contributions are relatively constant over time. When streamflow is low, point source discharges constitute a relatively larger proportion of the total streamflow. If an impairment is more pronounced at higher flows, as is the case with the fecal coliform impairment to Duck Creek, the pollutant is associated with stormwater runoff and is therefore nonpoint in nature. The critical condition was accounted for through the use of continuous watershed and water quality simulation models that accounted for storm-driven loading to Duck Creek. A continuous simulation allows the contribution of stormwater runoff under representative meteorologic conditions to be estimated.

## Water Quality Analysis

Very few data were available for the development of this TMDL. A total of 10 samples of total and fecal coliform bacteria were collected on two sampling dates by Alaska Water Watch (AWW), a volunteer monitoring program. Four of these samples exceeded the water supply criterion of 40 FC/100 mL. Nineteen total coliform and *Escherichia coli* (*E. Coli*) samples were collected by the Alaska Department of Environmental Conservation (ADEC). *E. coli* is a subset of fecal coliform bacteria, which in turn are a subset of total coliform bacteria. The applicable water quality criteria relate to fecal coliform bacteria. A relationship between *E. coli* and fecal coliform bacteria was assumed in order to estimate the fecal coliform counts associated with these 19 samples. Only one of the 19 estimates of fecal coliform bacteria developed using this relationship exceeded the 40 FC/100 mL criterion. The observed data were not sufficient to evaluate exceedance of the 30-day geometric mean standard of 20 FC/100 mL. The locations of the AWW and ADEC bacteria sampling sites are shown in Figure 2.

**Water Quality Data**

In general, the data available for the development of a fecal coliform TMDL for Duck Creek are characterized by spatially and temporally periodic water quality samples collected and analyzed for total coliform (TC), fecal coliform (FC), and *E. coli*. TMDL guidance (USEPA, 1991) provides that TMDLs should be developed using the best available information, especially when nonpoint sources are the primary concern.

*1994-1998 U.S. Geological Survey Streamflow Monitoring*

Daily streamflow has been measured since December 1993 at a United States Geological Survey (USGS) gaging station (15053200) downstream of Nancy Street in the Duck Creek watershed (Figure 2). The DCMP (Lorenz, 1998) indicates that flow at the gaging station represents discharges from approximately 75 percent of the watershed (approximately 810 acres). It is estimated that approximately 46 percent of the total precipitation that falls in the Duck Creek watershed is transported into the stream through overland runoff (Lorenz, 1998). The remaining 54 percent is believed to enter Duck Creek as groundwater or through sewer systems. Because flow in Duck Creek is heavily influenced by groundwater, there is a substantial lag between precipitation events and peak flow stages. Duck Creek has been observed to peak approximately 24 hours after the neighboring Jordan Creek. Peak monthly discharges and precipitation in the watershed occur on average during the months of September and October. This represents the period of maximum runoff and increased nonpoint source pollutant loading from areas in the Duck Creek watershed. Annual and monthly average flows and precipitation for 1994 to 1998 are presented in the Appendix, Table A-1.

*1992-1993 Alaska Water Watch Water Quality Monitoring*

During 1992 and 1993, local students from Juneau Youth Services, Miller House, collected water quality samples at nine sites in Duck Creek as part of the Alaska Water Watch (AWW) program. Parameters measured include water temperature, dissolved oxygen (DO), pH, turbidity, specific conductivity, alkalinity, and fecal coliform bacteria. Fecal coliform bacteria were collected at only five of the nine sites and are presented in the Appendix, Table A-2. The geographic

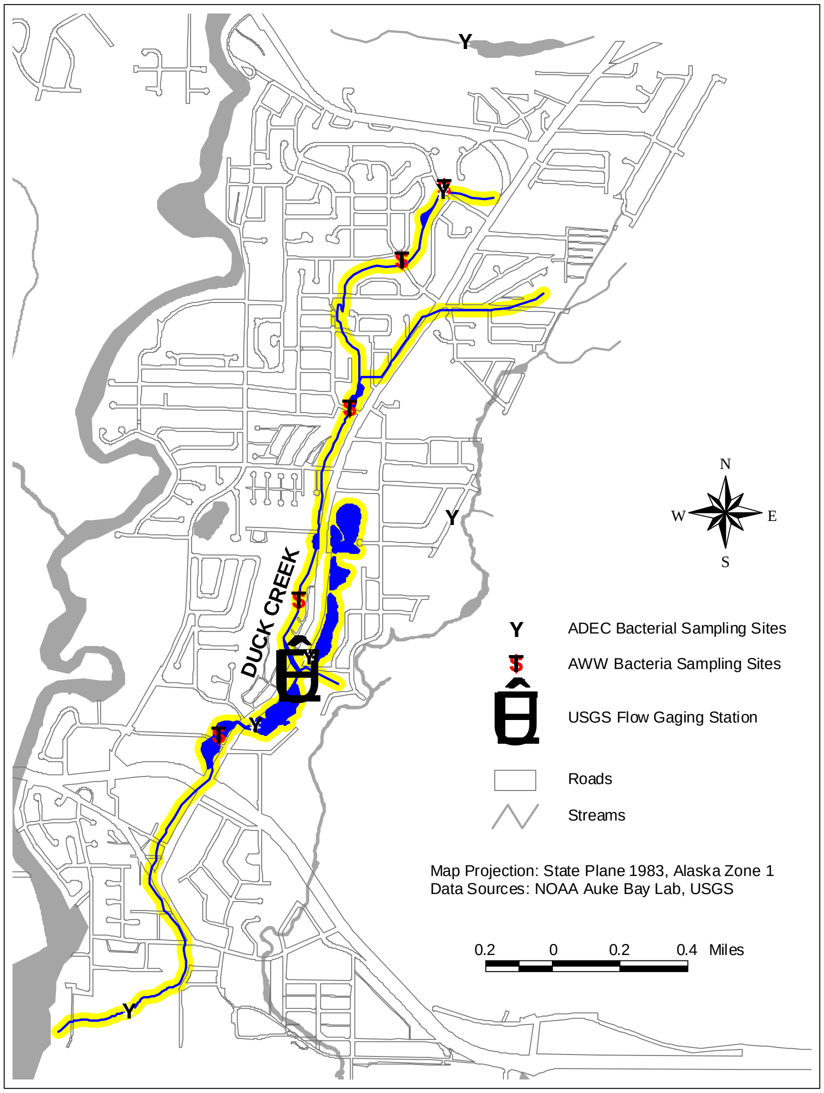


**Figure 2.** Location of AWW and ADEC bacteria sampling

locations of the five AWW coliform bacteria sampling stations are referenced by street names and are presented in Figure 2. The in-stream data collected at these sites did not have any corresponding flow, and the period of record did not have temporal overlap with the flow data collected at the Nancy Street USGS gaging station. For this reason, the coliform bacteria data available for two sampling events between 1992 and 1993 could not be used in model calibration. The values were, however, used to assess the frequency of exceedance of water quality standards.

### *1994-1995 and 1998 Alaska Department of Environmental Conservation Water Quality Monitoring*

During 1994 and 1995, ADEC collected water quality samples at five locations on three dates. The samples were analyzed for five-day biochemical oxygen demand ($BOD_5$), chemical oxygen demand (COD), nitrate ($NO_3$), nitrite ($NO_2$), sulfate, total coliform bacteria (TC), and *E. coli*. Four additional samples were collected in 1998 at four sites in response to questions regarding some fill material. The geographic locations of the ADEC coliform bacteria sampling stations are presented in Figure 2. These samples were the only bacteria data that coincided with the flow record available for the Duck Creek watershed. Table A-3 in the Appendix presents the ADEC total coliform and *E. coli* monitoring results.

## Analysis of Coliform Data

The Alaska water quality standard is based on fecal coliform bacteria, whereas the ADEC monitoring data were collected for total coliform bacteria and *E. coli*. Fecal coliform bacteria are a subset of total coliform bacteria, and *E. coli* is a subset of fecal coliform. Theoretically, a regression relationship between fecal coliform bacteria and *E. coli* in Duck Creek could be used to convert the ADEC *E. coli* values to their equivalent fecal coliform counts. However, no simultaneous measurements of fecal coliform bacteria and *E. coli* have been made in Duck Creek. A review of the literature found several equations relating fecal coliform bacteria and *E. coli*. The best available relationship is a set of regressions developed for wet and dry weather conditions in the Lower Geddes Pond in Michigan (LTI, 1999):

- Wet weather: *E. coli* = 0.7601 * fecal coliforms ($R^2$ = 0.9307)
- Dry weather: *E. coli* = 0.7308 * fecal coliforms ($R^2$ = 0.415)

Because the major sources of fecal coliform bacteria in Duck Creek are nonpoint and storm-related sources, the wet weather regression was used to calculate fecal coliform counts from the *E. coli* observations. The ADEC *E. coli* observations and their corresponding fecal coliform values are presented in Table 2.

**Table 2.** ADEC *E. coli* observations and calculated fecal coliform values

| Sampling Site | Date | *E. coli* (MPN/100mL) | Fecal coliform (MPN/100mL) |
|---|---|---|---|
| Dredge Lake | 10/10/94 | 4 | 5 |
| | 2/6/95 | 9 | 12 |
| | 4/17/95 | 2 | 3 |
| Taku Blvd | 10/10/94 | 8 | 11 |
| | 2/6/95 | 2 | 3 |
| | 4/17/95 | 2 | 3 |
| | 4/18/98 | 2 | 3 |
| | 4/18/98 | 2 | 3 |
| | 4/18/98 | 2 | 3 |
| Rainbow Row | 10/10/94 | 30 | 39 |
| | 2/6/95 | 4 | 5 |
| | 4/17/95 | 2 | 3 |
| Nancy Pond | 4/6/98 | 5 | 7 |
| Stump Lake | 10/10/94 | 23 | 30 |
| | 2/6/95 | 17 | 22 |
| | 4/17/95 | 2 | 3 |
| Airport Rd | 10/10/94 | 13 | 17 |
| | 2/6/95 | 80 | 105 |
| | 4/17/95 | 2 | 3 |

All of the available in-stream measurements were combined by parameter and station to evaluate trends and possible exceedances of the water quality standards. The AWW data suggest the impounded water between Taku Boulevard and Nancy Street is a source of elevated coliforms. The ponds in this area might attract wildlife such as ducks. When compared, the data from AWW and ADEC for Taku Boulevard are consistent. Without flow data, however, the AWW data can not be used to estimate downstream impacts. The data that overlap the flow record were used to determine relationships with flow. Figure 3 shows the monitoring data for fecal coliform counts versus the flow at Nancy Street.

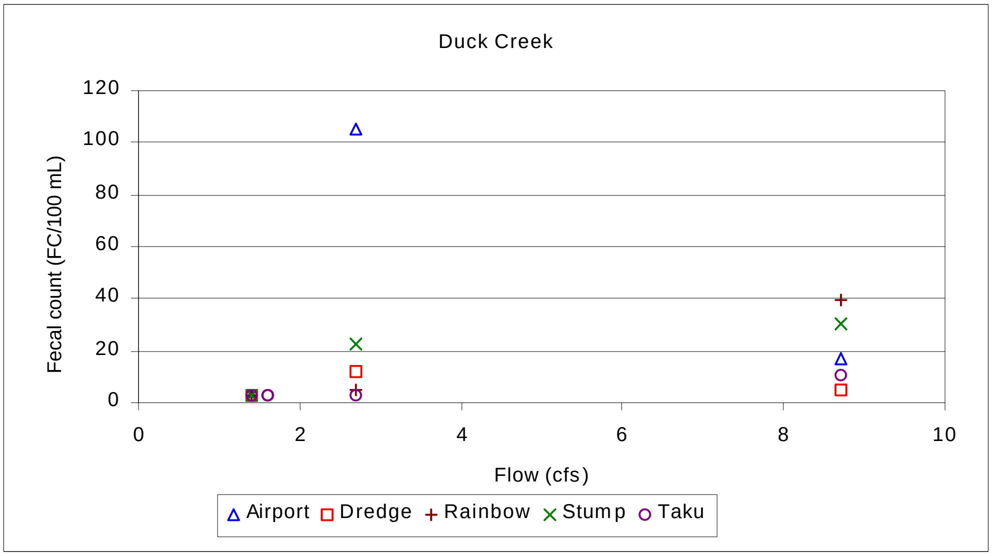


**Figure 3.** Observed fecal coliform bacteria per 100 mL vs. flow at Nancy Street

## Pollutant Sources

An assessment of potential fecal coliform sources is needed to evaluate the type, magnitude, timing, and location of the bacteria loading to Duck Creek. The source assessment includes identification of the various types of sources (e.g., point, nonpoint, background), determination of the relative location and magnitude of loads from the sources, and the transport mechanisms of concern. Of particular concern are the loading processes that cause the impairment. Loadings are often evaluated using a variety of tools, including existing monitoring information, simple calculations, spreadsheet analysis using empirical methods, and a range of computer models.

### Point Sources

No point sources are specified in the DCAG reports (Lorenz, 1998; Koski and Lorenz, 1999). A search of EPA's Permit Compliance System identified no point sources in the Duck Creek watershed. Because the entire Duck Creek Watershed is sewered, it is assumed that septic systems are not contributing to the fecal coliform impairment of Duck Creek (ADEC, personal communication, July 7, 2000).

There are no combined sewer overflows (CSOs) to the fecal coliform bacteria impairment of Duck Creek in the watershed, and no reported sewage leaks. However, if CSOs or sewage leakages are found in the Duck Creek watershed, then they should be corrected or controlled to the extent possible.

Due to the small size of Juneau, no municipal stormwater permits are currently required for this area. Therefore, urban runoff (storm water) is treated as a nonpoint source in this TMDL. In addition, there are currently no known industrial stormwater permits in this watershed.

Because of the lack of point source dischargers in the watershed, the wasteload allocation is set to zero.

### Nonpoint Sources

Fecal coliform bacteria are a constituent of human sewage and animal waste and can be found in natural waters. A few strains of coliform bacteria can produce serious human illness, but their abundance is primarily used to assess the potential for the presence of other more virulent pathogens associated with sewage (Lorenz, 1998). Nearly half of the Duck Creek watershed provides space for residential housing, yards, and driveways, and another third of the watershed is used for transportation, commercial, or industrial interests (Lorenz, 1998). Because of the nature of the Duck Creek watershed, it is likely that storm water runoff is the primary means by which fecal coliform bacteria are transported to the creek. There are many potential sources of fecal coliform in urban runoff, but the major sources in Duck Creek are thought to be wildlife (mainly ducks) and domestic pets (mainly dogs). A horse stable that was previously thought to contribute fecal coliform bacteria to Duck Creek has since been relocated outside the watershed. Because storm water runoff integrates many watershed sources into a single source, it is difficult to determine the magnitude of the loads from individual sources. The following sections do, however, provide an estimate of the relative contribution of what are believed to be the largest of these sources (ducks and dogs).

#### *Ducks*

It is estimated that there are approximately 50 ducks in residence along Duck Creek (ADEC, personal communication, July 7, 2000). The American Society of Agricultural Engineers has found that on average, ducks produce $2.43 \times 10^9$ fecal coliform bacteria per animal per day (ASAE, 1998). The estimated production of fecal coliform bacteria by ducks in Duck Creek is therefore calculated to be $4.43 \times 10^{13}$ fecal coliform bacteria per year.

#### *Dogs*

It is estimated that there are approximately 1,250 dogs in residence in the Duck Creek watershed (ADEC, personal communication, July 7, 2000). Horsely and Whitten (1996) estimate that, on average, dogs produce $5 \times 10^9$ fecal coliform bacteria per animal per day. The estimated production of fecal coliform bacteria by dogs in Duck Creek is therefore calculated to be $2.28 \times 10^{15}$ fecal coliform bacteria per year.

The estimates presented above suggest that domestic dogs contribute the vast majority of the total nonpoint source fecal coliform load in urban runoff, with ducks contributing the remaining 2 percent.

## Analytical Approach

Development of TMDLs requires a combination of technical analysis, practical understanding of important watershed processes, and interpretation of watershed loadings and receiving water responses to those loadings. In identifying the technical approach for development of the fecal coliform TMDL for Duck Creek, the following core set of principles was identified and applied:

- *The TMDL must be based on scientific analysis and reasonable and acceptable assumptions.* All major assumptions have been made based on available data and in consultation with local agency staff.
- *The TMDL must use the best available data.* All available data in the watershed were reviewed and were used in the analysis when possible or appropriate.
- *Methods should be clear and as simple as possible to facilitate explanation to stakeholders.* All methods and major assumptions used in the analysis are described, with additional detail provided in the appendix. The TMDL document has been presented in a format accessible by a wide range of audiences, including the public and interested stakeholders.

The analytical approach used to estimate the loading capacity, existing loads, and load allocations presented below relies on the above principles and provides a TMDL calculation that uses the best available information to represent watershed and in-stream processes.

### Modeling Approach

The objective of this section is to document and summarize the hydrologic and water quality modeling approaches applied to estimate in-stream fecal coliform concentrations and loadings in the Duck Creek watershed. The Storm Water Management Model (SWMM) simulates the quantity and quality of runoff produced by storms in urban watersheds (USEPA, 1997). SWMM allows for the representation of mixed-land-use watersheds using continuous simulation based on observed meteorologic conditions. At the subwatershed scale, SWMM provides for evaluation of in-stream conditions, allowing for direct comparison with the relevant water quality standards. The model represents Duck Creek as a series of hydrologically connected subwatersheds.

Hydrologic and water quality simulations of the watershed were performed for Duck Creek. The modeling approach used included continuous simulation of rainfall and runoff, as well as in-stream fecal coliform concentrations. Flow and in-stream fecal coliform concentrations and loadings were simulated as time series and summarized based on the subwatershed annual loadings. The estimates of in-stream concentrations and pollutant loadings to Duck Creek are used to estimate the existing conditions in Duck Creek and to develop an allocation scenario that results in attainment of Alaska's water quality standards and minimizes the frequency of standard exceedances.

### *Model Setup*

The Duck Creek system consists of the main stem and two major tributaries, El Camino and the East Fork. To capture the spatial distribution of the fecal coliform sources, the watershed was subdivided into six subwatersheds (four main stem and two tributary). The main stem, Duck Creek, was subdivided into four segments that coincide with sampling locations and tributary junctions. The main stem segments are

- Segment 1 - Above Taku
- Segment 2 - Taku to El Camino
- Segment 3 - El Camino to Nancy Street
- Segment 4 - Nancy Street to Mouth

### *Model Input*

Hourly precipitation and climate data from Juneau Airport (504100) were not available for the simulation period (January 1, 1994 to January 1, 1996). Hourly precipitation data from Annette WSO Airport (AK0352) and Yakutat WSO Airport (AK9941) were combined using a normal-ratio method to create a continuous hourly precipitation record for the Duck Creek watershed. For the most recent 7 years of data, 1990 to 1996, a statistical summary of rainfall indicates that the mean annual rainfall is 69.6 inches with a maximum of 88 inches, a minimum of 55 inches, and a standard deviation of 12.3 inches. The simulation period, 1994 to 1996, was considered to be representative of the long-term annual and seasonal variability of rainfall in the watershed because of the similarity of the standard deviations for the simulation period and for the period of record.

### *Hydrologic Simulation*

Existing data indicate that the number of fecal coliform bacteria is highest during higher flow events. To account for the delivery of fecal coliform loads during runoff-producing events, it was necessary to develop a model that captures the watershed runoff and the in-stream hydrologic regimes. The SWMM model was set up using data on watershed characteristics that influence runoff volume (e.g., land use distribution and percent imperviousness), and the available flow record from the Nancy Street gage. Once the model was calibrated to existing hydrology, it was used to simulate the effects of existing loadings on in-stream fecal coliform concentrations, as well as the load reductions necessary to attain water quality standards.

### *Water Quality Simulation*

After calibrating the hydrologic component of SWMM, water quality was simulated by developing fecal coliform accumulation rates using information obtained on the number of animals and their typical fecal coliform counts. In the model, the fecal coliform loading to Duck Creek was established as the relationship between fecal coliform buildup (which, among other things, is a function of time between runoff-producing events) and the wash-off of the buildup. The fecal coliform buildup was assumed to behave in a linear fashion; that is, it accumulates at a uniform rate and continues to accumulate at that rate (with no maximum) until some fraction is washed off during a storm event of sufficient intensity and duration. The uniform buildup rate was adjusted to obtain a best fit for monitoring data at Taku Boulevard and Nancy Street, Segments 1 and 3, respectively. Segment 4 was compared to Airport Road, which is located at the lower half of Segment 4. Once calibrated to the existing monitoring data, the model was used to simulate a continuous existing condition.

## Loading Capacity

One of the essential components of a TMDL is identifying and representing the relationship between the desired condition of the stream (expressed as the water quality standard) and pollutant loadings. Once this relationship has been established, it is possible to determine the capacity of the waterbody to assimilate fecal coliform loadings and still attain water quality standards.

It is estimated that 75 percent of the watershed (810 acres) drains to the USGS gaging station at Nancy Street. Duck Creek currently experiences flow losses in the reach downstream of the Nancy Street station, to the point that flow is entirely absent from this reach during certain parts of the year. Since no data is available on flow rates below Nancy Street, this analysis assumes that flow is conserved from Nancy Street to the mouth of the creek at Radcliff Road. Several management options have been proposed to restore flow in this reach, including lining the streambed to prevent flow losses to groundwater and flow augmentation (Koski and Lorenz, 1999).

Using available flow and water quality monitoring data, a 2-year simulation period (January 1, 1994 to January 1, 1996) was used to estimate the loading capacity of Duck Creek for fecal coliform bacteria. The results of that simulation are presented in Table 3 for the four main stem segments modeled. The loading simulated in each model segment is input into the next downstream segment during the simulation. The loading capacity for the TMDL is therefore represented by the loading in the most downstream segment, segment 4.

**Table 3.** Loading capacity of Duck Creek for fecal coliform bacteria

| Segment Number | Segment Name | Simulated Flow (Total $ft^3$)* | Loading Capacity (Total FC)* | Loading Capacity (FC/yr) |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | Above Taku | $2.55 \times 10^{7}$ | $1.05 \times 10^{11}$ | $5.23 \times 10^{10}$ |
| 2 | Taku to El Camino | $7.58 \times 10^{7}$ | $2.66 \times 10^{11}$ | $1.32 \times 10^{11}$ |
| 3 | El Camino to Nancy | $1.31 \times 10^{8}$ | $3.84 \times 10^{11}$ | $1.92 \times 10^{11}$ |
| 4 | Nancy to Mouth | $1.79 \times 10^{8}$ | $4.68 \times 10^{11}$ | $2.34 \times 10^{11}$ |

* Based on a two-year simulation.

Existing conditions were simulated for the same time period. For that two year period, the model predicted 106 exceedances of the 20 FC/100 mL 30-day geometric mean standard and 4,534 exceedances of the 40 FC/100 mL 10 percent not-to-exceed standard. Table 4 shows the predicted fecal coliform standard exceedances for the existing conditions scenario in Duck Creek for the four main stem segments modeled.

**Table 4.** Predicted exceedances of the water quality standards in Duck Creek under the existing conditions scenario

| Segment Number | Segment Name | 20 FC/100 mL 30-day geometric mean (daily model output) | | 40 FC/100 mL 10% not-to-exceed (hourly model output) | |
|---|---|---|---|---|---|
| | | Number of Exceedances | Percent Exceedances | Number of Exceedances | Percent Exceedances |
| 1 | Above Taku | 46 | 6.6% | 1,547 | 8.8% |
| 2 | Taku to El Camino | 42 | 6.0% | 1,342 | 7.6% |
| 3 | El Camino to Nancy | 19 | 2.7% | 930 | 5.3% |
| 4 | Nancy to Mouth | 9 | 1.3% | 715 | 4.1% |

## Wasteload Allocation

Because no point sources contribute to the fecal coliform impairment to Duck Creek, and because any CSOs that might contribute to the impairment must be controlled, the wasteload allocation is set to zero.

## Load Allocation

The load allocation was determined for the nonpoint source loads contributing to each of the segments of Duck Creek. The load allocation is expressed as an annual total number of fecal coliform bacteria by segment. This load allocation is indicative of a source loading reduction applied throughout the year that will result in meeting water quality standards. It is assumed that BMPs used to control stormwater-driven nonpoint sources will be effective throughout the year, not just during storm events. Annual allocations for each segment are shown in Table 5. The loading capacity for the TMDL is represented by the loading in the most downstream segment, segment 4, and is equivalent to the loading capacity minus a five percent explicit margin of safety. The segment names associated with each segment number are the same as those presented in Tables 3 and 4. The results of the loading allocations are shown in Figure 4.

**Table 5.** Fecal coliform loadings to Duck Creek under the existing conditions and allocation scenarios

| Segment Number | Simulated Flow (Total $ft^3$)* | Existing Conditions (Total FC)* | Allocation (Total FC)* | Existing Conditions (FC/yr) | Allocation (FC/yr) | Percent Reduction |
|---|---|---|---|---|---|---|
| 1 | $2.55 \times 10^{7}$ | $1.64 \times 10^{11}$ | $9.96 \times 10^{10}$ | $8.17 \times 10^{10}$ | $4.98 \times 10^{10}$ | 39% |
| 2 | $7.58 \times 10^{7}$ | $4.15 \times 10^{11}$ | $2.53 \times 10^{11}$ | $2.07 \times 10^{11}$ | $1.26 \times 10^{11}$ | 39% |
| 3 | $1.31 \times 10^{8}$ | $5.98 \times 10^{11}$ | $3.66 \times 10^{11}$ | $2.99 \times 10^{11}$ | $1.83 \times 10^{11}$ | 39% |
| 4 | $1.79 \times 10^{8}$ | $4.46 \times 10^{11}$ | $4.46 \times 10^{11}$ | $3.62 \times 10^{11}$ | $2.23 \times 10^{11}$ | 38% |

* Based on a two-year simulation.

The allocation scenario loadings resulted in no exceedances of the geometric mean criterion. The not-to-exceed criterion was exceeded 2.2 percent of the time over the 2-year simulation period, thus, attaining the load allocations will lead to the attainment of Alaska's fecal coliform bacteria criteria for Duck Creek. The total number of predicted exceedances for the allocation scenario is shown in Table 6.

**Table 6.** Predicted exceedances of the water quality standard in Duck Creek under the allocation scenario

| Segment Number | Segment Name | 20 FC/100 mL 30 day geometric mean (daily model output) | | 40 FC/100 mL 10% not-to-exceed (hourly model output) | |
|---|---|---|---|---|---|
| | | Number of Exceedances | Percent Exceedances | Number of Exceedances | Percent Exceedances |
| 1 | Above Taku | 0 | 0.0% | 678 | 3.9% |
| 2 | Taku to El Camino | 0 | 0.0% | 537 | 3.1% |
| 3 | El Camino to Nancy | 0 | 0.0% | 226 | 1.3% |
| 4 | Nancy to Mouth | 0 | 0.0% | 137 | 0.8% |

### Margin of Safety

This section addresses the incorporation of a margin of safety (MOS) into the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loadings) or a combination of both.

Because of the dual nature of the standard for fecal coliform bacteria, the MOS was included in this TMDL both implicitly and explicitly. Several conservative assumptions were made in the modeling approach, creating an implicit margin of safety. These included:

- The use of a linear buildup rate for fecal coliform: other buildup methods, such as

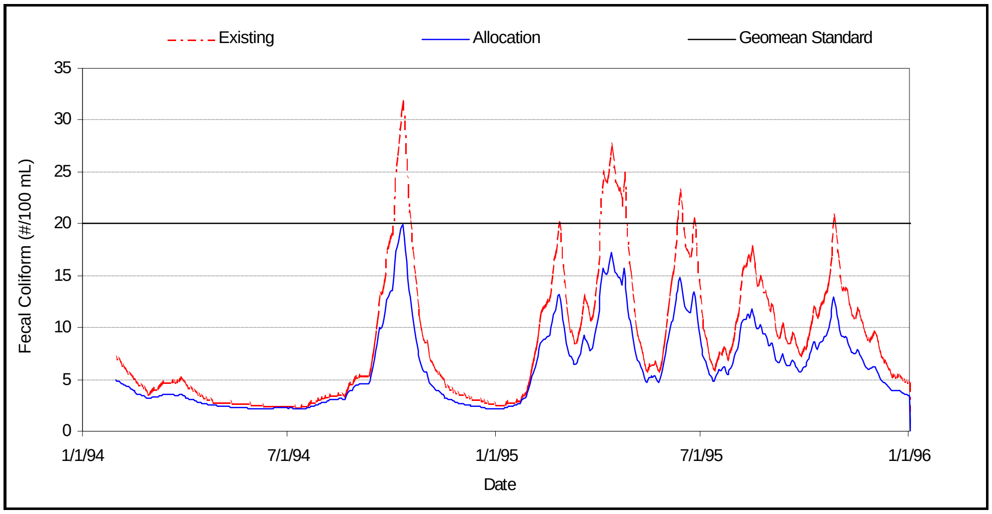


**Figure 4.** Existing conditions and allocation scenarios for Duck Creek

  exponential buildup, would yield slower buildup in the first few days after a storm. Given the high frequency with which rain events occur in Juneau, a linear buildup rate will tend to estimate a higher amount of fecal coliform bacteria.
- No maximum was placed on the amount of fecal coliform bacteria buildup: in the field, fecal coliform bacteria will generally buildup to a maximum level at which the rate of buildup is

balanced by the rate of die-off. No such maximum level was used in the model, allowing higher levels of buildup to occur between storms.

In addition to these implicit assumptions, an explicit MOS was included in the analysis by reducing loads to meet a target in-stream concentration of 38 FC/100 mL, which is equivalent to a 5 percent MOS relative to the not-to-exceed 40 FC/100 mL more than 10 percent of the time criterion.

## Monitoring

Very limited data were available to support the development of this TMDL. The AWW observations believed to have been the basis for listing Duck Creek for fecal coliform bacteria did not have any corresponding flow values. And the ADEC data that coincide with the flow record were actually *E. coli* observations from which fecal coliform values had to be estimated. Recognizing these inherent uncertainties, EPA has encouraged the development of TMDLs using available information and data with the expectation that a commitment to additional monitoring will accompany the TMDL (USEPA, 1991). This approach allows proceeding with source controls while additional monitoring data are collected to provide a basis for reviewing the success of the TMDL. This approach enables stakeholders to move forward with resource protection based on existing data and less rigorous analysis.

The past and current coliform bacteria monitoring activities in the Duck Creek watershed have been minimal and are outlined in the water quality analysis section of this TMDL (and in the DCMP). Although the status of future monitoring programs is unknown, it is anticipated that water quality and flow monitoring will continue at the USGS sampling stations in the watershed. The collection of coliform bacteria data at these stations is strongly recommended. The monitoring data collected at these sites will provide data that

- Verify the assumption that urban runoff and animal waste, from both domestic pets and wildlife, are the primary nonpoint sources of fecal coliform in Duck Creek.
- Assess improvements in water quality.
- Verify the regression relationship applied to fecal coliform bacteria and *E. coli*.

In addition to continued collection of data at the USGS stations, water quality monitoring by other involved state and federal agencies (e.g., ADEC, National Marine Fisheries Service) and volunteer groups should continue in a coordinated manner.

The focus of the monitoring program should be on the assessment of stormwater, in-stream conditions, and impacts of stream restoration projects on water quality. The parameters sampled should include flow, total coliform bacteria, fecal coliformbacteria, and *E. coli* at a minimum, and sampling sites should be distributed along the length of the stream. The monitoring will provide information on in-stream improvements and show long-term trends. Implementation monitoring is often cited as the most cost-effective of the monitoring types because it provides information on whether restoration efforts are having the desired effect on water quality. Specific projects that potentially affect water quality conditions should be monitored to determine their immediate on-site effects.

Although it is not feasible to develop a detailed monitoring plan at this time, it is expected that upon TMDL adoption, participating parties will develop a cost-effective monitoring plan to assess the effectiveness of the restoration of Duck Creek.

## Possible Future Actions

### Public Education, Outreach, and Participation

The DCAG was formed in 1993 to coordinate, plan, initiate, and carry out activities to restore water quality and anadromous fish habitat in Duck Creek. The DCAG provides education and facilitates work with the City and Borough of Juneau, state and federal agencies, private businesses, conservation organizations, and homeowners in the design of restoration projects and pollution control throughout the watershed. The MWP coordinates restoration projects, public education and outreach, and volunteer activities. Some of the activities sponsored by the MWP include the following:

- Adopt-a-stream: community groups volunteer to help keep streams in the Mendenhall watershed litter-free.
- Storm drain stenciling: the message “Dump No Waste, Drains to Stream” is stenciled on storm drains to let residents know that waste dumped into storm drains is transported directly to streams without treatment.
- Public education and events: field trips, community forums on important watershed issues, and technical workshops on erosion control and water pollution prevention are organized.
- Youth education: the MWP and Discovery Southeast host “Watershed Discovery Days” for youth to explore, do hands-on science, and help with a stewardship project in the watershed.
- Restoration projects: examples of projects include wetland habitat restoration and stabilization of eroding stream banks.
- Smart development: the MWP has worked with local builders and landowners to prepare user-friendly maps that will help them design their projects with better information about watershed resources.
- Flood control: record flooding in 1998 demonstrated the need for hydrologic studies of the watershed. MWP funding supports the USGS hydrologic studies in the valley.

Public attitude and perception toward the importance of Duck Creek are already changing as a result of the work done by the DCAG, MWP, and other community organizations. Public awareness of the impacts of urban runoff and animal waste on fecal coliform contamination in small streams such as Duck Creek will help foster a sense of ownership and a demand for stricter enforcement of water quality standards.

### Restoration and Management

Environmental standards and the substantial loss of aquatic resources in the watershed will require that significant restoration work be done. The process of restoring the watershed can and should be used to achieve community objectives beyond compliance with environmental standards. The DCAG has identified two areas in which restoration efforts should be focused—water quality and fish habitat. It recommends that water quality restoration efforts should concentrate on the creation of wetlands to treat stormwater, the development of riparian greenbelts to serve as stream buffers, and the reduction of dissolved iron levels in the stream. Fish habitat restoration efforts should focus on the restoration of stream hydrology, including reduced flooding and increased streamflow, and improved stream crossings.

A number of demonstration projects have already been completed, including several improved stream crossings, better snow management, streambank revegetation, sediment removal and channel reconfiguration, and wetland creation. Planned projects include additional stream crossing improvements, wetland creation and riparian zone revegetation, control of dissolved iron, streamflow restoration, streambed lining or sealing, fine sediment removal, and public access and education. The selection and implementation of restoration projects should be balanced with residents' concerns regarding drainage and flood control, while focusing on storm water treatment and wetland management. Current and planned projects aimed at restoring wetlands, streamflow and streamside vegetation will be particularly useful in addressing the fecal coliform impairment to Duck Creek by increasing streamflow and filtering pollutants from runoff before it reaches the stream. The following projects and activities would also help address this impairment:

- Encourage the cleanup and proper disposal of pet waste by pet owners.
- Use BMPs to help control urban runoff (e.g., constructed wetlands, infiltration basins, grass swales).

## Public Comment

The proposed TMDL is open for public comment from August 15, 2000 to September 15, 2000. People wishing to comment on the proposed TMDL should do so in writing by the close of the public comment period, September 15, 2000. All comments should include the name, address, and telephone number of the commenter and a concise statement of the comment and the relevant facts upon which it is based. Written comments must be postmarked by the close of the comment period and sent to Randall F. Smith, Director, Office of Water, USEPA Region 10, 1200 Sixth Avenue, Seattle, WA 98101. Comments may be faxed to EPA at (206) 553-0165 and e-mailed to carlin.jayne@epa.gov by the close of the public comment period.

## Appendix: Water Quality and Flow Monitoring Data

### 1994-1998 U.S. Geological Survey Streamflow Monitoring

**Table A-1.** Streamflow data from USGS gaging station at Nancy Street (15053200) and precipitation from NCDC Juneau International Airport Station (504100) from 1994 to 1998

| **Year**[a] | | | **1994** | | **1995** | | **1996** | | **1997** | | **1998** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual mean flow (cfs) | | | 3.87 | | 2.65 | | 3.67 | | 3.85 | | 3.75 | |
| Annual runoff (acre-feet/yr) | | | 2,800 | | 1,920 | | 2,660 | | 2,790 | | 2,710 | |
| Annual precipitation (in/yr) | | | 68.89 | | 46.35 | | 60.45 | | 74.62 | | 53.20 | |
| Annual precipitation (acre-feet/yr) | | | 6,200 | | 4,170 | | 5,440 | | 6,720 | | 4,790 | |
| **Month**[b] | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Flow (cfs) | 1.70 | 2.30 | 2.52 | 2.76 | 2.49 | 2.00 | 2.76 | 3.61 | 6.72 | 7.52 | 3.92 | 4.31 |
| Precipitation (in/month) | 3.27 | 4.77 | 4.25 | 3.10 | 2.86 | 3.50 | 5.43 | 5.27 | 8.74 | 8.27 | 4.32 | 6.92 |

[a] Annual values are summarized by calendar year.
[b] Monthly values are averages for 1994 to 1998.

### 1992-1993 Alaska Water Watch Water Quality Monitoring

**Table A-2.** AWW total and fecal coliform monitoring results

| Sampling Site | Date | Total coliform (MPN/100mL) | Fecal coliform (MPN/100mL) |
|---|---|---|---|
| Taku Blvd | 6/30/92 | 110 | 2 |
| | 8/2/93 | 90 | 2 |
| Mendenhall Blvd | 6/30/92 | 130 | 13 |
| | 8/2/93 | 170 | 2 |
| McGinnis Dr | 6/30/92 | 1,600 | 1,600 |
| | 8/2/93 | 1,600 | 700 |
| Kodzoff Acres | 6/30/92 | 1,600 | 500 |
| | 8/2/93 | 900 | 20 |
| Mendenhall Mall Rd | 6/30/92 | 500 | 17 |
| | 8/2/93 | 3,500 | 400 |

## 1994-1995 and 1998 Alaska Department of Environmental Conservation Water Quality Monitoring

**Table A-3.** ADEC total coliform and *E. coli* monitoring results

| Sampling Site | Date | Total coliform (MPN/100mL) | *E. coli* (MPN/100mL) | Notes |
|---|---|---|---|---|
| Dredge Lake | 10/10/94 | 900 | 4 | |
| | 2/6/95 | 33 | 9 | |
| | 4/17/95 | 27 | 2 | |
| Taku Blvd | 10/10/94 | 500 | 8 | |
| | 2/6/95 | 14 | 2 | |
| | 4/17/95 | 50 | 2 | |
| | 4/18/98 | 5 | 2 | Between sample wells 2 & 3 |
| | 4/18/98 | 2 | 2 | Downstream |
| | 4/18/98 | 2 | 2 | Above Culvert |
| Rainbow Row | 10/10/94 | 90 | 30 | East Fork |
| | 2/6/95 | 130 | 4 | East Fork |
| | 4/17/95 | 300 | 2 | East Fork |
| Nancy Pond | 4/6/98 | – | 5 | East Fork |
| Stump Lake | 10/10/94 | 170 | 23 | |
| | 2/6/95 | 80 | 17 | |
| | 4/17/95 | 80 | 2 | |
| Airport Rd | 10/10/94 | 130 | 13 | |
| | 2/6/95 | 1,600 | 80 | |
| | 4/17/95 | 900 | 2 | |

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